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REPORT NO. T13/85

PERFORMANCE ON SELECTED CANDIDATE SCREENING TEST PROCEDURES BEFORE AND AFTER ARMY BASIC AND ADVANCED INDIVIDUAL TRAINING

U S ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

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The purpose of this project was to evaluate a strength screening procedure to be used in Military Entrance Processing Stations (MEPS) for matching the strength capacity of recruits with the strength demands of Military Occupational Specialties (MOSs). Prior to the study, a task analysis was performed and all Army MOS were fit into a 5 category modified Department of Labor classification system based on lifting requirements. In order to determine the best single screening test for lifting ability, five candidate test items were performed by 1,984 Army recruits prior to Basic Training (BT). The tests, chosen for face

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validity, proven reliability, and historical precedence, were isometric handgrip, isometric 38 cm upright pull, incremental dynamic lift, skinfold determination of body composition, and a submaximal prediction of maximal oxygen uptake. At the end of Advanced Individual Training (AIT) 970 of the same subjects were re-tested on the candidate test items, and on a series of job related criterion performance tasks (CPTs). Candidate test item norms for male and female soldiers are presented for pre and post BT, and for post-AIT. The two training phases had a significant positive effect on muscle strength, aerobic fitness and body composition. The incremental dynamic lift to 152 cm was found to be the best predictor of CPT performance and was selected for implementation as the Military Entrance Physical Strength Capacity Test (MEPSCAT). An evaluation of the effectiveness of the MEPSCAT is currently in progress and will be reported elsewhere. As less than 15% of the females in the heavy lifting MOS categories were actually strength qualified for their MOS at the end of AIT, one of several conclusions may be drawn: a) 85% of these females were not capable of completing all MOS tasks; b) the MOS was not properly categorized; c) an inability to lift the required weight on the IDL does not accurately reflect upon job performance. These data clearly show that a need exists for an accurate test of strength capacity prior to MOS assignment.

Keywords:

HUMAN RESEARCH

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

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TECHNICAL REPORT

No. T 13/85

Performance on Selected Candidate Screening Test Procedures Before and After Army Basic and Advanced Individual Training

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Project Reference No: 3E162777A879

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FOREWORD

In 1977 with the increasing influx of women into the military services, the Army realized that a system of matching the individual physical capacity of the soldier to the physical demands of military occupational specialties was needed. On 25 July 1977, the Deputy Chief of Staff for Personnel tasked USARIEM, through The Surgeon General's Office, "to develop, for pilot testing, a battery of physical fitness tests suitable for screening new accessions for MOS classification".

The Exercise Physiology Division carried out research studies in response to this tasking from 1978 to 1980 with recommendations submitted to ODCSPER in September 1980. No action was taken at that time due to perceived adverse impact on personnel utilization. However, continued pressure revived the issue and on 15 July 1982, USARIEM was again tasked to "develop and validate a gender-free military enlistment physical strength capacity test". This report presents the results of our research responding to this tasking.

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ABSTRACT

The purpose of this project was to evaluate a strength screening procedure to be used in Military Entrance Processing Stations (MEPS) for matching the strength capacity of recruits with the strength demands of Military Occupational Specialties (MOSs). Prior to the study, a task analysis was performed and all Army MOS were fit into a 5 category modified Department of Labor classification system based on lifting requirements. In order to determine the best single screening test for lifting ability, five candidate test items were performed by 1,984 Army recruits prior to Basic Training (BT). The tests, chosen for face validity, proven reliability, and historical precedence, were isometric handgrip, isometric 38cm upright pull, incremental dynamic lift, skinfold determination of body composition, and a submaximal prediction of maximal oxygen uptake. At the end of Advanced Individual Training (AIT), 970 of the same subjects were re-tested on the candidate test items, and on a series of job related criterion performance tasks (CPTs). Candidate test item norms for male and female soldiers are presented for pre- and post BT, and for post-AIT. The two training phases had a significant positive effect on muscle strength, aerobic fitness and body composition. The incremental dynamic lift to 152 cm was found to be the best predictor of CPT performance and was selected for implementation as the Military Entrance Physical Strength Capacity Test (MEPSCAT). An evaluation of the effectiveness of the MEPSCAT is currently in progress and will be reported elsewhere. As less than 15% of the females in the heavy lifting MOS categories were actually strength qualified for their MOS at the end of AIT, one of several conclusions may be drawn: a) 85% of these females were not capable of completing all MOS tasks; b. the MOS was not properly categorized; c. an inability to lift the required weight on the IDL does not accurately reflect upon job performance.

These data clearly show that a need exists for an accurate test of strength capacity prior to MOS assignment.

INTRODUCTION

The US Army is a highly diversified organization and trains enlisted soldiers for more than 350 different military occupational specialties (MOSs). Training for these specializations is often expensive and time consuming, and a reliable method of helping soldiers select an MOS suitable to their unique mental and physical abilities seems prudent. Until recently, the Army screening procedures included the Armed Services Vocational Aptitude Battery (ASVAB), a medical examination and a written questionnaire regarding moral qualification. This information was then used in a job counselling session. Although the ASVAB provides information concerning specific areas in which the applicant should excel, it is based on cognitive measures, and gives no consideration to the physical demands of the MOS. A reliable physical capacity screening system would benefit the Army by reducing injury related costs, as well as the cost of re-training soldiers not physically capable of performing their chosen MOS. Benefits to the individual soldier include reduced risk of work related injury and greater job satisfaction.

The purpose of this study was to develop a physical strength screening tool called the Military Entrance Physical Strength Capacity Test (MEPSCAT). The MEPSCAT had to be safe, easily administered and gender free for use in the Military Entrance Processing Stations (MEPS). The MEPSCAT would be used in conjunction with current measures to help channel recruits into an MOS for which they meet the physical requirements.

BACKGROUND

The concept of screening job applicants for physical capabilities has received much attention recently (2,5,12,18). The main reasons for this interest are the loss in revenue due to inefficient labor practices, the high cost of medical care and worker compensation and the large influx of women into traditionally male vocations. Business and industrial concerns are required to employ minorities as a certain percentage of their work force to avoid claims of discrimination and these quota systems have provided innumerable vocational opportunities for women and minorities. There are problems inherent in this hiring practice, however, such as muscle strength differences and socio-cultural expectations. For example, the lower body strength of women is approximately 72% that of men, while their upper body strength is only about 55% that of men (11). Although these strength differences are reduced when considered relative to body weight, it represents the greatest problem in incorporating large numbers of women into the manual labor force.

Several attempts have been made by industrial and military concerns to develop valid screening procedures for physically demanding jobs which are safe, easily administered and not racially or sexually biased. The standard approach begins with a task analysis to determine the physical demands of the job. Next, the tests to measure the prospective employees' ability to meet the physical demands are developed. Validation of the selected testing procedures is the final step in the process. A discussion of this procedure follows, with illustrative examples from industry and the military. Specific attention will be given to the history of occupational pre-employment screening research projects of the US Army that led to the current project.

The first step in the development of an employee screening test is to identify the limiting tasks or requirements of the job. The task analysis is generally accomplished through survey, interview and observation of incumbents. The essential job tasks identified can then be quantified in terms of requisite physiological parameters, such as strength, flexibility, and aerobic demand. The US Army began this process in 1976, when experienced MOS training school instructors were surveyed, and many interviewed, to define and quantify the physical demands of the 352 Army MOSs (21). One important finding in this and similar job task analyses (2,12,18) was the importance of muscle strength and material handling skills in successful job performance. Lifting and lifting and carrying ability was an important task element in virtually every physically demanding job analyzed and accounted for about 90% of the physically limiting tasks of Army MOS's (19).

As it is unwieldy to consider the essential job tasks for each enlisted MOS, it was necessary to group MOS according to similarity of task and workload. The limiting tasks for each MOS identified were fit into a unique classification system. The system considered two categories of physical capacity: aerobic capacity and muscle strength requirements of the job (22). These muscle strength and aerobic requirements were divided into high, medium and low demand categories based on the amount of weight lifted, and the estimated energy cost of the most demanding task of that MOS. All MOSs were then grouped into five clusters of strength and aerobic demands as depicted in Table 1. The screening test development for the 5 cluster MOS physical demand classification system proceeded according to plan, but the MOS classification system was not implemented. In 1981 the Office of the Deputy Chief of Staff for Personnel showed a renewed interest in physical screening procedures for new accessions, and created the Women in the Army Policy Review Group

(WITAPRG) to repeat the task analysis/MOS grouping procedures. The WITAPRG selected a modified Department of Labor (DOL) classification system to categorize Army MOSs. The modified DOL system is based solely on lifting requirements with no consideration given to non-lifting tasks such as whole body mobility tasks which are limited by aerobic demands. The modified DOL system chosen for final implementation is shown in Table 2 (25).

TABLE 1

USARIEM MOS PHYSICAL DEMAND CLASSIFICATION SYSTEM

MOS Cluster	Lifting Capacity	Aerobic Capacity
ALPHA	>40 kg	>2.25 l/min
BRAVO	>40 kg	1.5 -2.25 l/min
CHARLIE	>40 kg	<1.50 l/min
DELTA	30-40 kg	<1.50 l/min
ECHO	<30 kg	<1.50 l/min

TABLE 2

ARMY MODIFIED DOL PHYSICAL DEMAND CLASSIFICATION SYSTEM

	Lifting Requirement	
	Occasional (<20% of time)	Frequent (20%< of time <80%)
LIGHT	9.0 kg	4.5 kg
MEDIUM	22.7 kg	11.3 kg
MODERATELY HEAVY	36.3 kg	18.1 kg
HEAVY	45.3 kg	22.7 kg
VERY HEAVY	>45.3 kg	>22.7 kg

With the physically demanding elements of a job or MOS identified and quantified, the next step in the procedure is to develop safe, reliable tests to predict these abilities. For a single job or type of job, this process is relatively simple. A series of physical performance screening tests are selected on the basis of the physical requirements of the job. The physical performance tests are administered to a group of new employees and their subsequent job performance is rated in order to validate the screening tests. Pre-employment screening test scores are correlated with job performance ratings, and a multiple regression equation is developed to predict successful job performance from the parameters measured. This methodology was used to predict telephone lineperson performance and resulted in the use of body density and static strength measures as pre-employment tests(18).

The US Army's great diversification and size present special problems in the selection of screening tests and in the validation of these predictive tests. The screening tests and the criterion tasks must be generalized to represent the physical demands of a large number or cluster of jobs of similar physical intensity. The generic criterion tests selected in 1978 to represent the demands within an MOS cluster were maximum lifting capacity (MLC) to represent all manual material handling tasks, and maximal oxygen uptake ($\dot{V}O_2max$) to represent all aerobic, whole body endurance tasks (19).

Two initial studies conducted by this Institute addressed the problem of developing predictive tests for the MLC and $\dot{V}O_2max$ criterion tasks of the 5 cluster MOS physical demand classification system. In a project at Ft Jackson, SC in 1978 a submaximal heart rate multiple step test was evaluated for estimating $\dot{V}O_2max$. The $\dot{V}O_2max$ of 42 male and 44 female recruits was measured directly pre- and post-basic training using an interrupted treadmill protocol. A squared multiple regression correlation coefficient (R^2) of .84 was obtained using gender, step test score and percent body fat to predict $\dot{V}O_2$ max. As the step test required specialized equipment and considerable test time, it was deleted from the prediction equation with a resultant decrease in R^2 of only .02 (19).

The purpose of a second study at Ft Stewart, GA in 1979 was to determine adequate predictors of the MLC criterion task, a lift to 132 cm (MLC132). This criterion measure, described later in more detail, consisted of lifting a steel box with padded handles to a platform 132 cm high. Weight was added with each lift until the subject was unable to complete the lift. A series of six isometric strength tests and the MLC132 test were administered to 182 male and 43 female soldiers from the 24th Infantry Division at Ft Stewart. Anthropometric, body composition and isometric strength measures were included

in a multiple regression analysis to predict MLC132. The final equation for prediction of lifting capacity included lean body mass, isometric upright pull strength and gender, and produced an R^2 of .62 (19).

In September 1980, as a result of these two studies it was recommended that in order to predict the aerobic and lifting capacities of new recruits, two tests should be implemented into the MEPS screening process: a skinfold determination of body composition, and an isometric pulling force test. Due to uncertainties of the impact on manpower of any physical classification system, decision on implementation was deferred.

By 1981 pressure had again mounted on the Department of the Army to resolve the problem of matching individual soldier capacity with job demand. The Office of the Deputy Chief of Staff decided to repeat the MOS task analysis according to the modified Department of Labor system already mentioned and depicted in Table 2. Upon completion of that analysis, this Institute was again tasked to evaluate the previously developed test items, and an additional one proposed by the Air Force: a maximum dynamic lift to 72", which was developed from an earlier lift test called the Factor-X (14).

The final step, or validation of the occupational screening procedures should examine both the ability to predict performance of the criterion tasks, and the effectiveness of the system in improving personnel utilization. In order to do this, it is necessary to implement the testing procedures on the targeted population and maintain careful records concerning job success, injury and attrition rates. As the proposed screening system was not implemented, this type of longitudinal data are not available.

A project involving telephone linepersons provides an example of this validation procedure (18). Following administration of a 12 item test battery, 210 new employees were observed and evaluated throughout a self paced

training period and during the first four weeks of actual job performance. The time to training completion, field observer ratings, accident reports and attrition rate were recorded and correlated with test battery results. Three test battery items were found to be successful predictors of accident rates and field observer ratings. Although the testing battery had a higher validity for women than for men, this was deemed appropriate, as women had higher injury and attrition rates.

For a large organization, such as the armed forces, the validation procedure is more difficult and perhaps more crucial. Tracking and obtaining attrition and injury rates, and job performance ratings of a representative sample of the military population is a massive undertaking. Consideration of the hundreds of different MOS performed at as many different work sites presents logistical and rater consistency problems. This task is now being examined by an Army study advisory group.

Brief mention should be made of the US Air Force initiatives in this area. In March 1976, the US Air Force implemented a strength screening procedure known as the Factor X test. The Factor X test was a machine lift of 20, 40, and 70 lbs to elbow height or 72" (13). Recruits received ratings of X-1 through X-4 (X-1=lift 70 lbs to 72", X-4=unacceptable). Recruits were matched with jobs within their rating category. The Factor X was implemented in the MEPS, and all Air Force personnel were tested in this manner. As 99% of all men and women fell into the X-1 and X-2 categories, the test was only useful in discriminating between very low strength individuals and all others. Also, as a task analysis revealed that many Air Force Specialty Codes made physical demands that substantially exceeded the ability to lift 70 lbs to 72", the test ratings did not meet the job requirements. In order to improve the classification process, the Air Force performed a more thorough task analysis,

designed a new lifting machine, and implemented a new testing procedure. The Air Force is currently attempting to validate this procedure. The experience of the Air Force illustrates the importance of actually implementing a new testing procedure on the targeted population, and tracking those subjects to determine procedure effectiveness.

The purpose of this report is to describe the results of the initial phase of the selection and validation of a strength capacity screening procedure based on the Army modified DOL classification system. The screening test selected is referred to as the MEPSCAT (military entrance physical strength capacity test). Evaluation of the effectiveness of the MEPSCAT is currently in progress and will be reported elsewhere.

STUDY DESIGN

The remainder of this report will discuss the involvement of the Exercise Physiology Division in selecting screening procedures to match the soldier to an MOS for which he/she is physically competent. As previously mentioned, the task analysis portion of the project was done by the WITAPRG. The Exercise Physiology Division was tasked with administration of potential screening tests to a representative sample of the Army recruit population in order to evaluate the screening tests, as well as to establish population norms. The Army Research Institute of Behavioral and Social Sciences was tasked to develop and collect data on criterion performance tasks deemed representative of Army jobs. All data discussed in this report is that collected by USARIEM Exercise Physiology Division personnel, unless otherwise noted.

The study design, outlined in Figure 1 consisted of three MEPSCAT candidate test administrations. Phase one (P1) was a pre-basic training measure used to determine entrance levels of strength and stamina of new military recruits. Nine hundred eighty males and 1004 females were tested at Ft Jackson, SC during September and October, 1982. Phase two (P2) was performed during the last week of basic training (BT) in November, 1982 at Ft Jackson on a subsample of the P1 group consisting of 89 males and 113 females. The purpose of P2 was to examine changes in fitness levels following 8 weeks of BT. The P2 subjects were given a maximum lift capacity test as a supplemental criterion measure of lifting ability. Phase three (P3) was administered to 466 males and 487 females from the original P1 group toward the end of their Advanced Individual Training (AIT) programs. The subjects

were tested at one of four posts (Ft Jackson, SC, Ft Cordon, GA, Ft Lee, VA, or Ft Sam Houston, TX) from January - March, 1983. A series of generic criterion performance tasks (CPT) were also performed by the subjects at this time. The CPTs were designed to simulate and represent "on the job" strength requirements such as pulling, pushing, lifting, carrying and applying torque. The MEPSCAT P1 descriptive data were then used to predict performance on the CPT battery P3. The CPT data were collected, analyzed and reported by Applied Research Resources Organization, a private contractor hired by the Army Research Institute (14). The MEPSCAT implementation procedures resulting from this collaborative effort will be discussed later in this report.

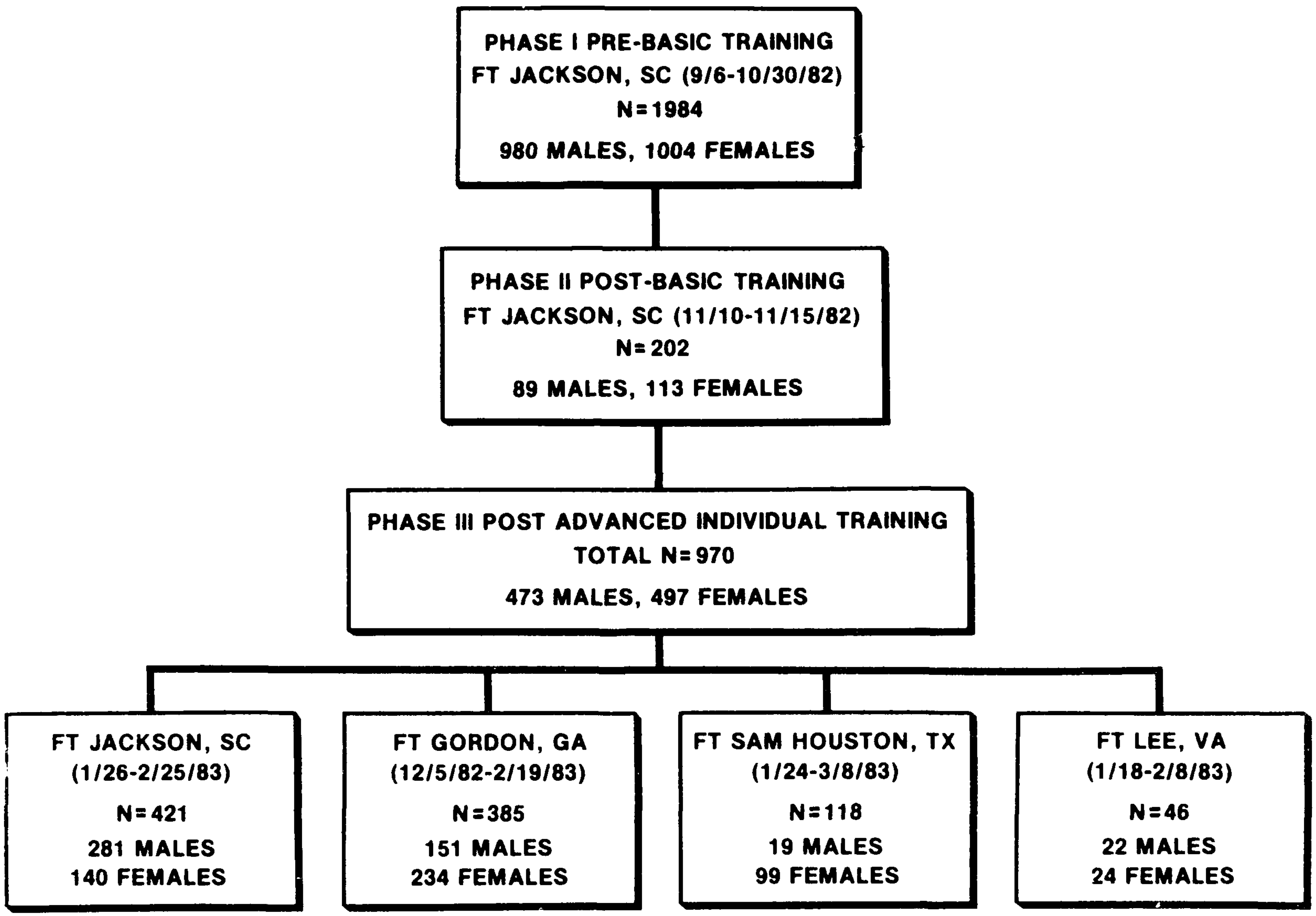


FIGURE 1. MEPSCAT STUDY DESIGN

METHODS/MEASURES

The initial test battery, which will be referred to as the MEPSCAT consisted of five candidate test items. The three strength tests included were isometric handgrip, isometric 38cm upright pull and an incremental dynamic lift to 152cm and 183cm. A four skinfold estimation of body composition was made and a bench stepping test or Astrand-Ryhming cycle ergometer test was administered to predict $\dot{V}O_2$max. A description of testing and scoring procedures follows. All tests were administered within a four hour period with adequate rest provided between tests.

Isometric Handgrip Strength (HG)

The handgrip apparatus and procedure was that of Knapik and Ramos (17). This test was selected because it is suggested to be a good indicator of whole body strength and is highly correlated (r=.82) with lean body mass (26). HG is also a safe, easily administered test that would be well suited for use in the MEPS. The device was adjustable to hand size with contoured grip surface as shown in Figure 2. The tension was transferred through a BLH Electronics C2M1 tension compression transducer. A digital readout of peak tension was obtained from a BLH Electronics transducer indicator model 450A. Calibration was checked prior to each session.

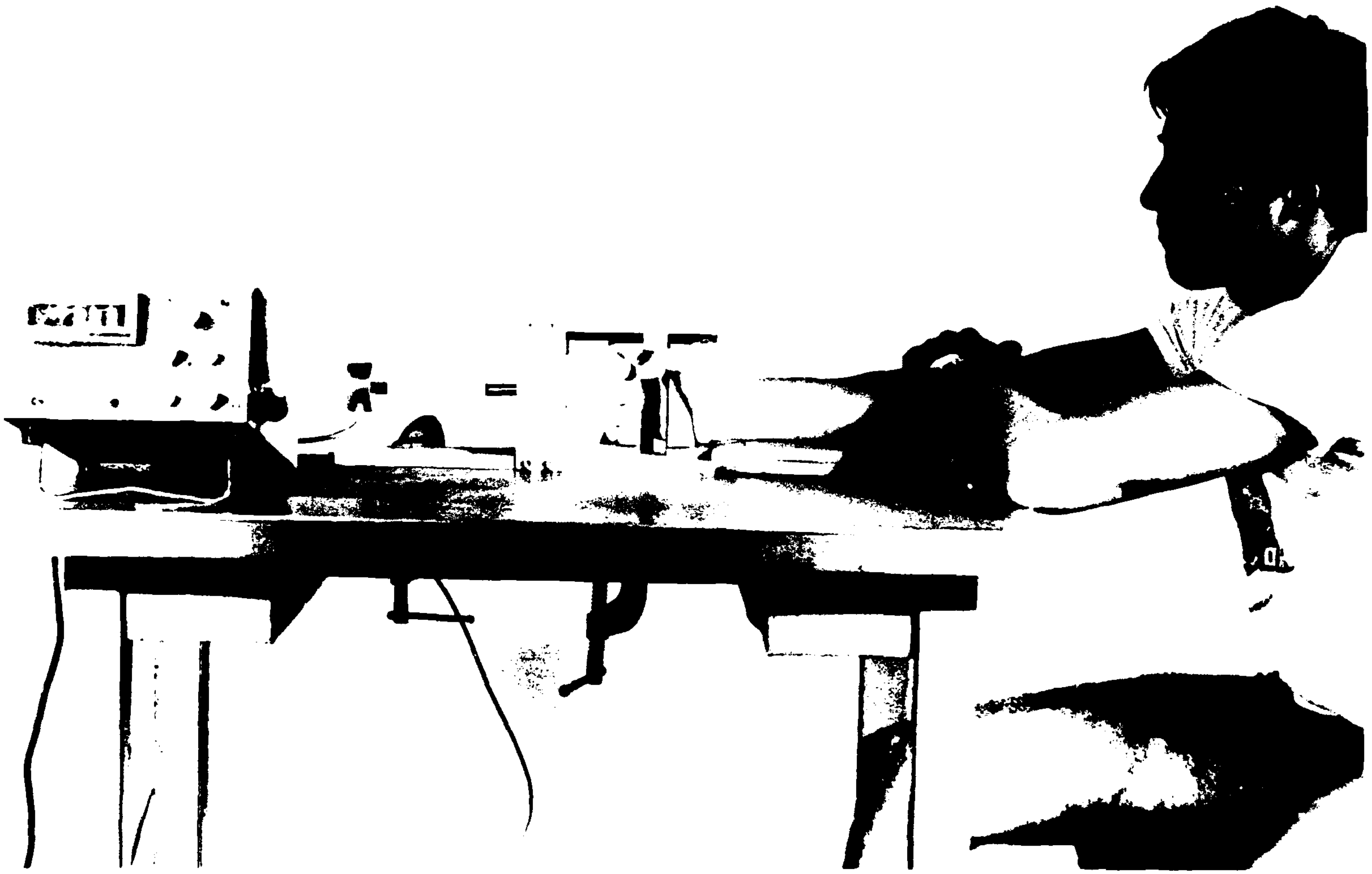


FIGURE 2. ISOMETRIC HANDGRIP TESTING DEVICE

Subjects were seated and received an explanation of the testing procedure. The apparatus was adjusted to allow an angle of 150° at the third metacarpalphalangeal joint and 110° at the proximal interphalangeal joint of the third finger of the right hand. Subjects were instructed to keep their forearm resting on the pad and build up to maximum HG strength over a period of 3-5 seconds. Subjects were verbally encouraged during each trial to produce a maximum force. Excessive or jerking movements resulted in a re-trial. Three trials were performed with a minimum of 45 seconds rest between trials.

The final score was the average of three trials. If the three trials were not within 10% of one another, additional trials were performed until three scores within the 10% range were obtained. A maximum of six trials were executed and a mean of the closest three scores was used as the final score. This HG testing procedure has been shown to have an intraclass reliability coefficient of R= .98 (17).

Isometric 38cm Upright Pull(38cm UP)

The apparatus and procedures used were those of Knapik, Vogel and Wright (10). The 38cm UP device consists of a taped aluminum handle attached by airplane cable to a BLH Electronics C2M1 transducer load cell mounted on a slip-proof wooden platform. The vertical distance from the platform to the horizontal axis of the handle was 38 cm. The load cell was attached to a BLH model 450A transducer indicator which provided a digital readout of peak isometric tension.

The 38cm UP was designed to test isometric lifting strength at the weakest position in the lift and has been shown to be significantly correlated (r=0.74) with lifting ability (26). The testing position was demonstrated for all subjects by the tester and each subject was verbally encouraged to produce a maximal force. The correct position is illustrated in Figure 3. The

subject stood parallel to and straddling the load cell. While maintaining a straight back with the head up, the subject was instructed to bend at the hip and knees to grasp the handle in a mixed grip with straight arms. On command, the subject was told to pull straight up building to maximum effort in three to five seconds. If the subject jerked upward or leaned in any direction, the trial was repeated. Three trials were performed with a minimum of 1 minute rest between trials.

The final score was the mean of three trials with the requirement that scores fall within 10% of one another. Up to six trials were performed to obtain three scores within the 10% range, and the three closest scores were included in the mean for the final score. A three trial intraclass reliability coefficient of .97 for 38cm UP has been previously reported (10).

FIGURE 3. 38cm UPRIGHT PULL TESTING DEVICE AND POSITION

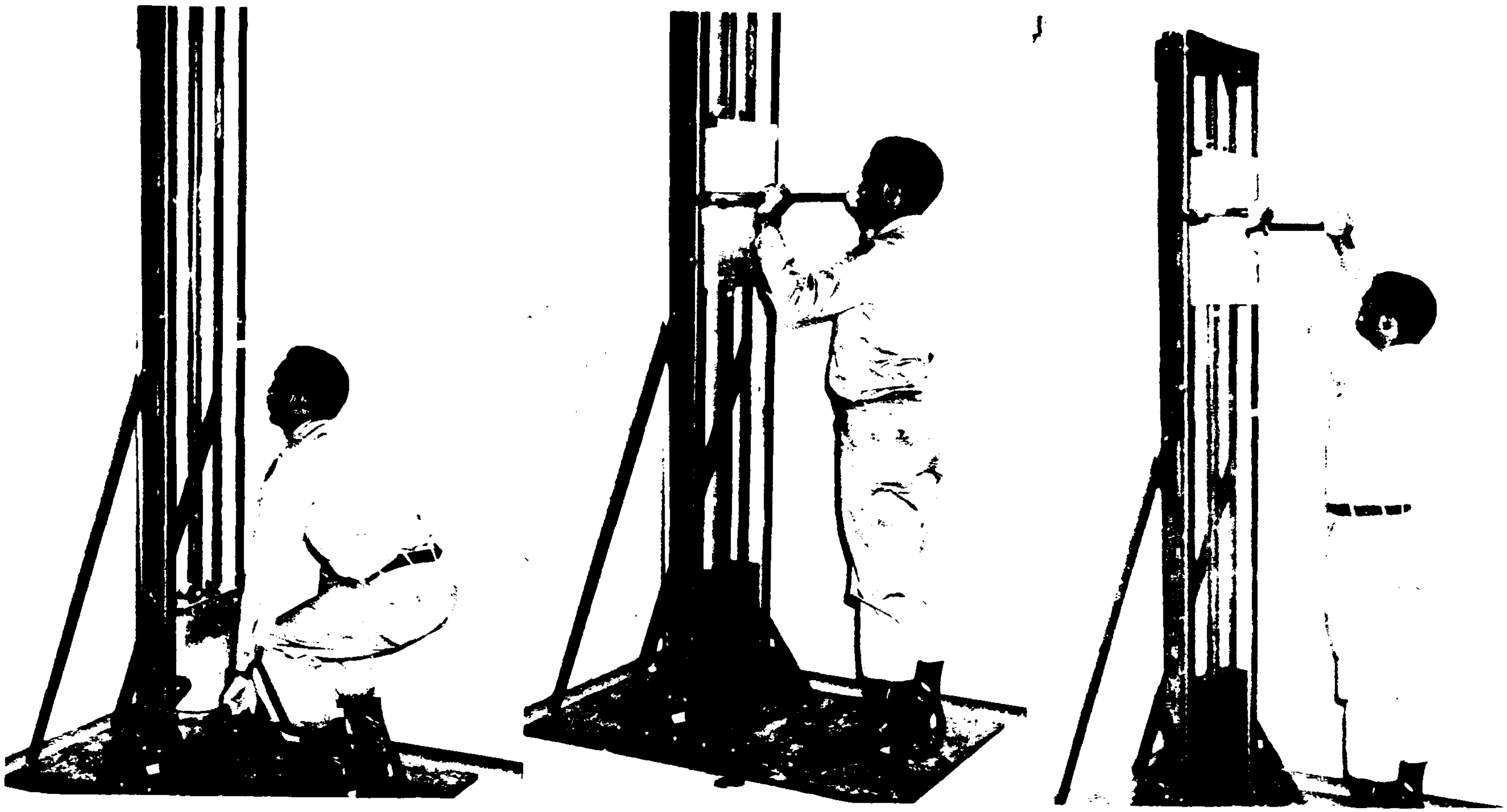
Incremental Dynamic Lift to 152cm and 183cm

The incremental dynamic lift (IDL) test was was designed by the Air Force to measure the maximum lifting capacity of recruits in a dynamic mode. The Air Force version of the incremental weight lift test requires recruits to lift to a height of 183 cm. We chose to lift to 152 cm which is the equivalent of lifting a box with handles 20 cm above the floor, onto the bed of a 2-1/2 ton truck. The 183 cm height was included to allow comparisons to the Air Force data base (13).

The design of the IDL, shown in Figure 4 was based on the Air Force Incremental Weight Lift test machine (13) with some minor modifications. The IDL is a free standing machine with a weight carriage assembly which rides vertically between upright support channels on low friction teflon rollers. The carriage assembly weighs 18.1 kg, and from zero to sixteen 4.5 kg weights may be added to the carriage by inserting a pin in the weight stack at the rear of the machine. The IDL has a load range of 18.1 - 90.9 kg. The weights are contained within the upright support channels, making it impossible to drop the weights in a manner which would cause injury to the subject or the tester. The weight carriage is shielded to prevent the subject from observing the amount of weight lifted. The knurled handgrips attached to the carriage were designed to provide a sure grip, maintain a safe distance between the subject and the machine, and are separated to allow room for the subjects knees between them. To facilitate testing, two marks were made on the vertical support rail and one on the carriage to indicate weight carriage handle heights of 183 cm and 152 cm above the platform.

The testing procedure was explained and demonstrated to the subject who then stood on the platform facing the IDL with his/her feet shoulder width

apart. While maintaining a nearly vertical torso, the subject was instructed to bend at the hip and grasp the handle with an overhand grip. The subject then attempted to lift the unweighted carriage (18.1 kg) in one continuous motion to the upper vertical support mark (183cm). For females, one weight plate (4.5 kg) was added to the carriage, and the lift was repeated. Males were incremented by two weight plates (9.0 kg), until they began to exhibit difficultly in lifting the carriage to 183cm, then one weight plate was added with each lift. If a subject failed to reach 183cm, but successfully lifted the carriage to 152 cm, the previous successful lift to 183 cm was recorded as the final IDL 183 score. The weight was increased and the subject attempted to lift that weight to 152 cm. When the subject was unable to lift the weighted carriage to 152 cm, the test was terminated. No rest was allowed between lifts other than the time needed for the technician to increase the load. Extreme care was taken to enforce a vertical torso lifting technique. If the subject rested the weight carriage at chest level and made more than one attempt to execute an overhead press, it was considered an unsuccessful trial and the previous lift was recorded as the final score. The correct lifting technique is illustrated in Figure 4. A technician was positioned beside the subject to assist in lowering the weight carriage whenever necessary. The final scores for the IDL test were the amount of weight (kg) successfully lifted to 183 cm and 152 cm. This procedure has been shown to have an intraclass reliability coefficient of .98 for one trial (20).



a. STARTING POSITION b. 152cm LIFT c. 183 cm LIFT

FIGURE 4. INCREMENTAL DYNAMIC LIFT TESTING TECHNIQUE

Aerobic Capacity Estimation

A submaximal cycle ergometer or bench stepping test was used to predict $\dot{V}O_2max$. The subject preparation for both tests requires application of three disposable electrodes; one to each shoulder sub-mid-clavicular and one in the V5 position. Lead wires connect the electrodes to a GW4600 series Cardio-Tach which provides a digital readout of heart rate. An electronic metronome was set at 100 BPM to establish the rhythm for both the cycling and stepping tests. The Astrand-Ryhming submaximal cycle ergometer test consisted of pedalling a Monark cycle ergometer (Model 868) at 50 rpm for six minutes (4). The initial exercise intensity was 125 watts for men and 100 watts for women. The testing procedure was described and the seat height of the ergometer adjusted. The subject began pedalling in time to the metronome and the resistance was added. Subjects were carefully monitored throughout the testing protocol to maintain proper pedalling cadence. The heart rate was observed after two minutes of cycling, and the resistance was adjusted to produce a final heart rate between 120-170 BPM. The heart rate was recorded every 15 seconds during the sixth minute of cycling. If the heart rate continued to rise during the sixth minute (>5 BPM), the test was continued for an additional minute, and heart rates were again recorded at 15 second intervals. A mean of the final four heart rate recordings was used to represent the final heart rate. The final (steady state) heart rate, cycling intensity, age and sex of the subject were recorded, and used to determine predicted $\dot{V}O_2max$.

The two step, five minute bench stepping procedure was developed for a study at Ft. Stewart in 1979 as a modification of the original four step, 12 minute procedure (19). The step test apparatus used is shown in Figure 5. Electrodes were applied and the subject was briefed on the testing protocol.

The initial step height was 20 cm for females and 30 cm for males. The tester instructed and monitored the subject until the correct stepping cadence of 25 complete cycles/minute was reached. Stepping cadence was carefully monitored throughout the testing procedure. The heart rate was observed after two minutes of stepping. If the heart rate was below 130 BPM after two minutes, the step height was raised to the next level and stepping continued for 3 additional minutes. If the heart rate was at or above 130 BPM, the subject continued at the same step height for 3 minutes. At the end of 5 minutes of exercise, the final heart rate, final step height, age and sex were recorded and used to determine predicted $\dot{V}O_2$ max.

The determination of predicted $\dot{V}O_2$max is essentially the same for the Astrand-Ryhming cycle ergometer test and the bench stepping test. A nomogram developed by Astrand and Ryhming(4) is entered with the intensity (kpm/min or step height) and frequency (RPM or step cycles/min) of the exercise mode, to provide an estimate of the oxygen consumption (ml/kg/min) at that workload. This estimation of $\dot{V}O_2$ is then used in equations 1 and 2 to estimate the $\dot{V}O_2$max of males and females, respectively.

[1] $p\dot{V}O_2max = (195-61)/(HR-61) \times \dot{V}O_2$

[2] $p\dot{V}O_2max = (198-72)/(HR-72) \times \dot{V}O_2$

195 and 198 represent population estimates of maximal heart rate and 61 and 72 represent resting heart rate for males and females respectively. As HR max generally declines with increasing age, Astrand (3) developed an age correction factor (M) for males and females as follows:

[3] $M(males) = 100/100 + 1.37(AGE) - 33.2$

[4] $M(females) = 100/100 + 1.14(AGE) - 23.0$

The final score is obtained by multiplying the predicted $\dot{V}O_2$ max (ml/kg/min) by the correction factor for age.

The correlation between the Astrand-Rhyming cycle ergometer prediction of $\dot{V}O_2max$ and a discontinuous cycle ergometer $\dot{V}O_2max$ has been reported to be r=.63 for a young military population (1). Previous studies of male and female Army recruits have found the MEPSCAT bench stepping protocol to be significantly correlated ($r=0.64$, $p<.01$) with a discontinuous treadmill $\dot{V}O_2max$ (26).

FIGURE 5. TWO LEVEL STEP TEST

Skinfold Estimation of Body Composition

Lean body mass (LBM) has been shown to be significantly correlated with muscle strength and aerobic capacity (19), and was therefore included in the MEPSCAT candidate test battery. The method used was that of Durnin and Womersley (9). Harpenden calipers were used to make the skinfold measurements. The mean value of three measures made at the biceps, triceps, subscapular and suprailiac were added together to obtain the sum of four skinfolds. The sum of the skinfolds, gender and age were needed to obtain an estimate of percent body fat. Equations 5 and 6 were utilized to determine body fat and lean body mass.

[5] Body Fat (kg) = %BF X Body weight

[6] LBM (kg) = Body Weight(100 - %BF)/100

Maximum Lift Capacity (MLC 132)

Maximum lift capacity was an additional test added to the MEPSCAT battery during P2. The MLC 132 was designed as a measure of the ability to lift heavy objects onto the bed of a 2-1/2 ton truck. The testing apparatus includes a steel box 45cm long X 31cm wide X 26cm deep. The padded steel handles are 20 cm above the bottom on either end. The empty box weighed 15.6kg, and weights ranging from 1.2 - 11.0 kg were used to increase the load. The maximum load lifted was 90.9kg to be compatible with the IDL 183 and 152. The weighted box was lifted to a flat topped wooden platform 132cm above the floor.

Safe lifting technique was demonstrated with emphasis on a straight back, bent knee approach. The subject was instructed to lift the box from the floor onto the platform. Two technicians stood on either side to assist if needed and were responsible for lowering the box. Weight was added with each successful trial until the S was unable to complete the lift. Subjects were tested in small groups with a minimum of 1 minute rest between lifts.

Four criteria were used to indicate trial failure:

1. Inability to place the weighted box on the platform.
2. Excessive hyperextension of the back or an attempt to angle the box onto the platform.
3. Halting or jerky motions during the course of the lift.
4. Back flexion during the initial portion of the lift.

The final score on MLC 132 was the last weight successfully lifted to the platform.

Although the Exercise Physiology Division was not given responsibility for the criterion performance tasks, the MLC 132 was included to enlarge the current data base and to examine the predictive capability of the new IDL procedure.

Statistical Analysis

The mean and standard deviation of all measures recorded over the three phases were determined for all subjects as well as for men and women separately. Analysis of variance (ANOVA) techniques were used to investigate the changes in strength, body composition, and aerobic capacity pre-Basic Training (P1) to post-Advanced Individual Training (P3). The ANOVA procedures were performed on the whole group and male-female and strength category sub-groups to examine changes in MEPSCAT battery performance within and between phases of training. Pearson product-moment correlations between all MEPSCAT and descriptive measures were examined. A series of multiple regression analyses were run to attempt to predict post-basic MLC 132 from MEPSCAT candidate test performance. These results and a discussion are presented in the following section of this report.

RESULTS AND DISCUSSION

Sample Descriptors

Nine hundred and eighty males and 1004 females completed the MEPSCAT candidate test battery P1. Approximately 1000 of these S's (515 males and 507 females) were tested on the CPTs at the end of their AIT (P3). The large initial sample size (1,984) was necessary in order to allow for expected attrition and tracking problems, while still providing an adequate sample size for comparison with CPT results. A large initial sample was also deemed necessary to capture representative numbers of male and female subjects from each of the five MOS lifting categories. The mean and standard deviation of each measure for males, females and the combined P1 sample are presented in Table 3.

As expected, the P1 data revealed significant differences between males and females on all measures. Males were significantly taller, heavier and leaner than females. The predicted aerobic capacity (p$\dot{V}O_2$max) of the males was 13% greater than that of the females which is slightly below the 15-20% reported by Drinkwater (7,8). This difference is not as great as has been previously reported for a similar military population (15), but the present group of male recruits seems to be at a lower initial level of cardiovascular fitness than the earlier reported sample. The differences noted may also be due to differences in measurement technique. Patton, Daniels and Vogel (15) measured $\dot{V}O_2$max directly on a treadmill while the MEPSCAT measurement was an indirect submaximal estimate based on cycle ergometer or step test exercise. The Astrand-Ryhming test has been shown to underestimate the $\dot{V}O_2$max of highly fit individuals (4).

TABLE 3
PRE-BASIC TRAINING DESCRIPTIVE DATA AND MEPSCAT
PERFORMANCE SCORES FOR THE TOTAL SAMPLE, MALES AND FEMALES SEPARATELY, AND THE FEMALE/MALE RATIO (MEAN±SD)

n	Combined 1984	Males 980	Females 1004	F/M Ratio (%)
Age(yrs)	20.0± 3.0	19.5± 2.5	20.4± 3.3	-
HT (cm)	168.8± 9.0	175.1± 6.8	162.6± 6.3	92.9
BW (kg)	65.6±11.5	72.9±10.8	58.5± 6.7	80.2
PBF	20.7± 6.4	16.2± 5.2	25.1± 3.9	154.9
LBM (kg)	52.1±10.2	60.7± 6.7	43.7± 4.2	72.0
BF (kg)	13.5± 4.7	12.2± 5.5	14.8± 3.5	121.3
$\dot{V}O_2max$(ml/kg/mn)	42.0± 6.5	44.4± 8.0	38.7± 7.8	87.2
HG (kg)	38.7±10.8	47.5± 7.4	30.2± 5.5	63.6
38cm UP(kg)	100.7±29.7	124.8±21.2	77.1±13.5	61.8
IDL 152 (kg)	45.1±17.5	60.6±10.7	29.8± 5.4	49.2
IDL 183 (kg)	41.0±17.5	56.7±10.5	25.6± 4.7	45.1

Females were able to lift 45% and 49% of the weight lifted by males on IDL 152 and IDL 183, respectively. These figures compare favorably to those reported by McDaniels (13) for male and female Air Force Basic Trainees. The HG strength of females was 64% that of males and 38cm UP of females was 62% that of the males. The female/male HG strength is within the 57-67% range reported in the literature (11,18,24), while the percentage female/male 38cm UP strength is on a par with that reported by Chaffin (6) of 58% for a similar task. The males in the MEPSCAT sample had consistently lower HG scores than those in the aforementioned studies of civilian males. As the MEPSCAT isometric strength scores are similar to those obtained at Ft Jackson in 1978 (19), differences between military and civilian populations may be due to differences in test equipment and administration.

The 1978 Ft Jackson study (19) and the present data both show the female to male strength ratio to be greater for isometric strength tests than isotonic tests. One possible explanation of this may be found in the nature of the tests involved. The IDL test used in MEPSCAT requires a movement

similar to the clean and jerk Olympic weight lift maneuver. This movement requires coordination and practice to execute smoothly and may have been more familiar to the males in the sample. The females were significantly shorter than males and therefore were required to use their upper body musculature during a greater percentage of the lift. This idea is supported by the fact that female scores were more comparable to male scores on the IDL 183cm than on IDL 152cm. The IDL 152cm is approximately chest height for most males, therefore it was unnecessary to press the weight overhead. In a review of the literature, Laubach (11) reports that females have approximately 64% of the trunk strength, 70% of the lower body strength, but only 56% of the upper extremity strength of males. Unlike the IDL, the 38cm UP does not isolate the upper body musculature and is heavily dependent on lower body and trunk strength. Because females were able to use the stronger musculature of their legs and trunk for the entire test, they were better able to match the strength of their male counterparts on 38cm UP. Also, as the 38cm UP is a difficult position for long legged individuals to assume, males may have been unable to apply force as efficiently as females. The key factor in the HG strength may be that it involves only a small amount of LBM for both males and females and little coordination is needed to perform it correctly.

It has been postulated that males are stronger than females due simply to a greater amount of muscle mass. In order to examine this hypothesis the muscle strength measures were divided by BW and LBM. A t-test was used to examine the relative strength differences between men and women. All strength measures continued to be significantly greater for males than females when considered relative to BW and LBM. These data are in Table 11 of Appendix II. The HG strength of females was 80% that of males when considered relative to BW and 89% when considered relative to LBM. These female/male percentages are

within the normal range of scores based on several studies reporting 65-85% for HG/BW and 78-87% for HG/LBM (11,24). 38cm UP female/male strength parity was increased to 76% when considered relative to BW and 85% relative to LBM. Females were still only able to lift 57% to 61% as much as males on IDL 183 and IDL 152, relative to BW. Relative to LBM, females lifted 64% as much as men to 183cm and 69% as much to 152cm. These data indicate that factors other than the amount of contractile LBM are responsible for differences in strength and lifting capacity between men and women. Some possible factors include muscle fiber type, motor unit recruitment firing patterns, state of training, and learning and skill on test performance. Although the data from this study provide no clue as to the mechanisms responsible, these differences between males and females must be considered when developing entrance strength requirements and training programs for military personnel.

Pre-Basic Training to Post-Advanced Individual Training (P1-P3)

Four hundred sixty five males and 487 females completed the MEPSCAT battery at both P1 and P3. The mean and standard deviation of all MEPSCAT battery measures are presented for males, females and the combined sample in Table 4. A one way ANOVA with predetermined alpha level of .01 was used to examine group changes from P1-P3. The combined group showed significant increases in BW, LBM, BF, $p\dot{V}O_2max$, HG, 38cm UP, IDL 152 and IDL 183. PBF showed no significant change from P1-P3. The combined group increases of approximately 3% in BW, BF and LBM are of little practical significance. A 13% increase in $p\dot{V}O_2max$ is within the 4-14% range reported for untrained people of the same age group undergoing a 10 week training program in a review of the literature by Pollock (16), and represents a significant improvement in aerobic fitness from P1-P3. HG, IDL 152 and 183 scores of the combined sample

were increased on the order of 10% from P1-P3 and 38cm UP strength was 17% greater during this same time period. These results indicate that the training process (Basic and Advanced Individual Training) is effective in improving the strength and aerobic fitness of the enlisted population. As the majority of the increase in BW was due to an increase in LBM, not BF, the body composition of the soldiers was also positively affected by the training procedures.

TABLE 4
P1-P3 DESCRIPTIVE DATA AND MEPSCAT PERFORMANCE SCORES FOR THE TOTAL SAMPLE AND MALES AND FEMALES SEPARATELY (MEAN±SD)

		Combined	Males	Females
n		952	465	487
Age (yrs)	P1	20.0 ± 3.0	19.2 ± 2.2	20.1 ± 3.2
Height (cm)	P1	168.9 ± 9.1	175.3 ± 6.8	162.7 ± 6.2
Weight (kg)	P1	65.1 ± 11.3	72.4 ± 10.3	58.1 ± 6.8
	P3	67.3 ± 10.0	73.9 ± 8.5	61.1 ± 7.0
Percent Body Fat	P1	20.4 ± 6.2	16.0 ± 5.0	24.7 ± 3.8
	P3	20.5 ± 6.5*	15.1 ± 3.8	25.6 ± 6.5
Lean Body Mass(kg)	P1	51.8 ± 10.1	60.4± 6.5	43.6 ± 4.4
	P3	53.7 ± 10.2	62.6 ± 6.3	45.3 ± 4.5
Body Fat (kg)	P1	13.2 ± 4.5*	11.9 ± 5.2	14.5 ± 3.4
	P3	13.6 ± 4.3*	11.3 ± 3.7	15.8 ± 3.6
$p\dot{V}O_2max$ (ml/kg/min)	P1	42.0 ± 8.3	46.9 ± 6.6	36.8 ± 6.5
	P3	49.4 ± 9.0	54.3 ± 7.8	44.1 ± 6.9
Handgrip (kg)	P1	38.8 ± 10.6	47.5 ± 7.1	30.5 ± 5.4
	P3	42.9 ± 11.6	52.6 ± 7.7	33.7 ± 5.6
38cm UP (kg)	P1	100.6 ± 29.7	125.1 ± 21.2	77.1 ± 13.0
	P3	121.4 ± 34.1	148.6 ± 24.8	95.2 ± 17.1
IDL 152 (kg)	P1	45.4 ± 17.5	60.9 ± 10.9	30.3 ± 5.3
	P3	49.8 ± 17.7	65.5 ± 10.[illegible]	34.4 ± 5.6
IDL 183 (kg)	P1	41.4 ± 17.4	56.9 ± 10.7	26.2 ± 4.7
	P3	46.1 ± 18.0	62.2 ± 10.9	30.4 ± 5.1

*No significant differnce from P1-P3 for the combined group. All other measures were significantly different from P1-P3, between males and females, and from P1-P3 within gender.

Males vs Females P1-P3

A significant increase in BW of 1.51kg in males and 2.98kg in females was found from P1-P3, a period of approximately 10-12 weeks. These changes are larger than those reported for male (+0.5kg) and female (+2.0kg) US Army soldiers (15), and for British male soldiers of +0.3kg (23) from pre- to post-

BT, a 6 to 8 week period. Examination of the subsample tested on MEPSCAT candidate tests pre- to post-BT (P1-P2) reveals a 0.5kg increase in BW of males and a 2.34kg increase in females (see Table 9, Appendix II). These BW changes are comparable to those previously mentioned for an identical training period. LBM was significantly greater in both males (2.14kg) and females (1.67kg) from P1-P3. PBF was not significantly different P1-P3, as males decreased by 0.9% and females increased by 0.95%. The increase in BW in males then, was entirely due to an increase in LBM, while in females the increase in BW was due to an increase in BF as well as LBM. As activity level and diet were not quantified, it is not possible to postulate on the reasons for male-female discrepancies in body composition changes from P1-P3. Changes in PBF of this magnitude are within the error of measurement of the skinfold technique.

The p$\dot{V}O_2$max increased 9% and 8% for males and females, respectively from P1-P3. This increase is greater than that reported by Patton, Daniels and Vogel (15) of 3.3% and 6.5% for a pre- to post-BT sample. However, the current P1-P2 subsample demonstrated approximately the same increase in aerobic fitness for females as the above study. These sample comparisons of aerobic capacity must be viewed with caution due to the differences in measurement technique (direct vs indirect) previously mentioned. The main determinant in percent increase in $\dot{V}O_2$max, all other variables held constant, is the initial level of $\dot{V}O_2$max. Drinkwater (8) reviewed the literature regarding $\dot{V}O_2$max changes with training in females and found an increase in $\dot{V}O_2$max of 13% or greater in low fit subjects ($\dot{V}O_2$max=33.2 ml/kg/min), while females who were more aerobically fit ($\dot{V}O_2$max=42 ml/kg/min) improved less than 13% with the same training stimulus. It appears that the males in the MEPSCAT sample were not as aerobically fit initially as those of Patton et al (15). This would account for the larger percent increase in aerobic capacity in the

MEPSCAT P1-P2 sample of males. The aerobic fitness level post-BT was equivalent for both males and females from the current sample and that of Patton, Daniels and Vogel (15). As no post-AIT data are available for the 1978 FT Jackson sample of Patton et al (15), it is not possible to directly compare P1-P3 improvements to them; however, MEPSCAT males and females continued to increase in aerobic capacity from P2-P3. These data appear in Appendix II, Table 10.

The HG strength of both males and females was significantly increased by approximately 10% from P1-P3. These increases were similar to those obtained by Wilmore (24) for college women involved in a 10 week weight training program 3 days/week. The males in Wilmore's study showed only a 5% increase in HG strength. The college age males were 3.8kg stronger than Army males upon initial testing but only 1.3kg stronger at the end of their respective training programs. This would indicate that the Army males were initially weaker than their college age counterparts, but were approximately equal to them in HG strength at the end of their training programs, thus achieving a greater percentage increase in strength. Males increased their 38cm UP strength by 16% from P1-P3, while females improved by 19%. This large increase in strength may be due to a learning effect as well as a strength increase. The female/male strength ratio was .62 during P1 testing and .64 during P3 illustrating a similar increase in strength for men and women in this study. These data agree well with that of Wright et al (26) who found a female/male ratio of .61 for experienced infantry soldiers.

IDL 152 was significantly increased from P1-P3 in males by 7% (4.6kg) and females by 12% (4.1kg). Significant increases of 5.3kg in males and 4.2kg in females were also found on IDL 183. The female/male strength ratio remained at approximately 0.50 from P1 to P3 for both lifting tests. Army and Air Force

males and females entered BT at approximately equal levels of IDL 183 strength (13). Although IDL 183 repeated measures data on Air Force personnel from a pre-BT to post-AIT were unavailable, comparison of MEPSCAT data to a pre-BT and a separate incumbent sample of Air Force personnel can be made. While MEPSCAT males demonstrated a 9% increase in IDL 183 strength from P1-P3, incumbent Air Force males (5) scored only 4% more than an independent sample of basic trainees (13). Females from the same two Air Force groups showed no differences between basic trainee and incumbent samples, while MEPSCAT females increased their IDL 183 strength by 14% from P1-P3. As no information was available concerning the sample of incumbent Air Force personnel, it was not possible to determine if such factors as age or detraining may have been operational. In a small pilot study (20), the test-retest reliability of the IDL 152 was 0.98. This high test-retest reliability tends to refute the argument that MEPSCAT subjects demonstrated an increase in IDL capacity simply due to a learning effect which was the result of repeated performance of the IDL 152 during P1 and P3.

MOS Physical Demand Categories

MEPSCAT participants were assigned to an MOS physical demand category based on their AIT MOS (see Table 2). The Light and Medium lifting categories were combined for all analyses because the minimum weight lifted on IDL 152 and 183 was 40 lbs (18.1 kg), which is greater than the light category (9.0kg) and less than the medium category (22.7kg) occasional lifting requirements. Although these soldiers were tested prior to BT, this muscle strength information was not used to counsel them during MOS selection. Several analyses were performed to examine the compatibility of soldier lifting capacity and MOS lifting requirements in an unscreened population, and to

determine if differences existed in strength, aerobic capacity or body composition between MOS categories before or after training.

TABLE 5
PERCENTAGE OF SOLDIERS STRENGTH QUALIFIED FOR CONTRACTED MOS

		LIGHT MEDIUM	MODERATELY HEAVY	HEAVY	VERY HEAVY
Male	n	113	12	70	268
	Pre-BT	100%	100%	96%	86%
	Post-AIT	100%	100%	100%	95%
Female	n	149	2	124	202
	Pre-BT	97%	50%	1%	0%
	Post-AIT	100%	100%	12%	1%

Table 5 contains the percentage of males and females strength qualified for their selected MOS pre-BT and post-AIT, as well as the number of subjects in each of these groups. The majority of male and female soldiers who selected a light-medium (LT-M) or moderately heavy (MH) category MOS, seem capable of meeting the requirements for that category following AIT. When all P1-P3 females were considered, regardless of assigned MOS, only 21% were able to qualify for the MH group by lifting 36.3kg prior to BT. 100% of P1-P3 males were strength qualified for this category. The heavy (HY) and very heavy (VH) lifting categories were not attainable for 99% of all P1-P3 females tested prior to BT. Ninety six percent and 89% for the P1-P3 males qualified for HY and VH MOS categories, respectively, prior to BT. Following 8 weeks of BT and 8-20 weeks of AIT, 7% of all P1-P3 females were able to lift 45.3kg and 1% lifted more than 45.3kg, thus qualifying for the HY and VH MOS categories, respectively. This is graphically illustrated in Figure 6. Of the females who qualified, less than 50% selected an MOS in the HY or VH categories. Thus, of

the 326 P1-P3 females trained for a HY or VH MOS, only 17 were actually strength qualified to perform their duties. Of the 338 P1-P3 males trained for a HY or VH MOS, only 14 were not able to lift the required amount following AIT. It appears that a more intensive weight training program may be required to enable women to satisfactorily perform in HY and VH category MOSs.

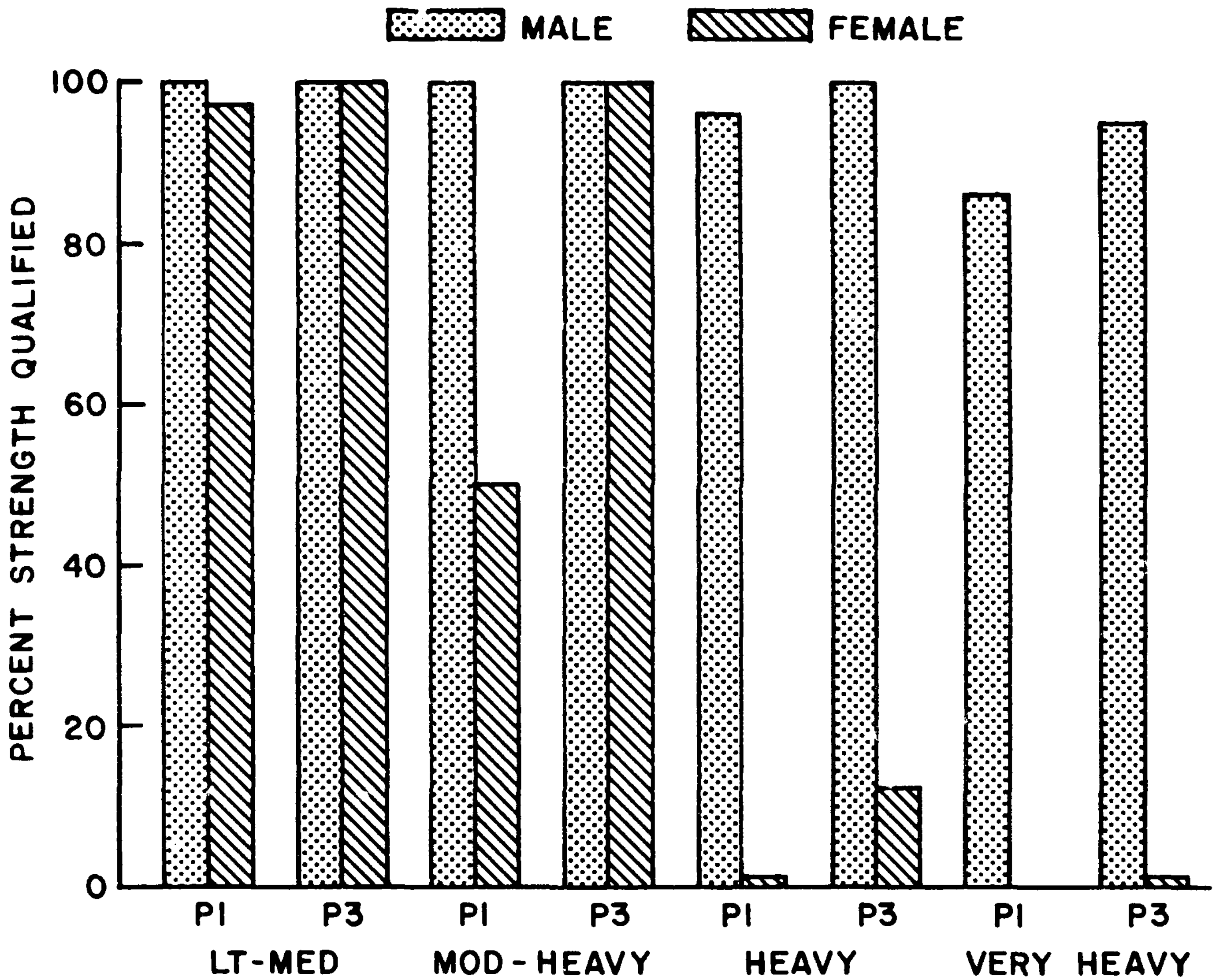


FIGURE 6. PERCENTAGE OF MALES AND FEMALES STRENGTH QUALIFIED FOR THEIR CONTRACTED MOS PRE-BT AND POST AIT.

A three way analysis of variance was performed to examine differences among MOS categories for males and females from P1-P3. The MH category was dropped from this analysis due to the small number of subjects it contained (n=14). The only differences deemed of interest in this analysis were those pertaining to MOS category main effects and interactions, as the significance of differences between males and females and pre-BT to post AIT have already been discussed. No significant differences were found for males or females between MOS categories P1 to P3 in body composition, $p\dot{V}O_2max$, HG or IDL 183cm. Significant differences ($p<.01$) were found between MOS categories for age, 38cmUP, and IDL 152cm. As the differences between males and females have already been established, a second analysis was performed on males and females separately to isolate the source of the MOS category differences. Females in the VHY category were significantly older than females in the LT-M category, but no significant differences in age were found for males. A significant difference of 2.7kg was found in IDL 152cm between the female LT-M and HY MOS categories. This difference is of little practical significance, as it is less than the smallest IDL weight increment of 4.5 kg. No significant differences were found among male MOS categories. A significant MOS category effect was found for the 38cm UP. When males and females were analyzed separately, females again showed an MOS category effect while males did not. A Tukey test did not show an honestly significant difference between any of the female MOS categories on 38cmUP. The differences in $p\dot{V}O_2max$, body composition and strength measures P1-P3 between MOS demand categories for males and females are depicted in Figures 7 and 8. Data for the total P1, P2 and P3 samples for males and females in each MOS category are available in Tables 12, 13 and 14 of Appendix II.

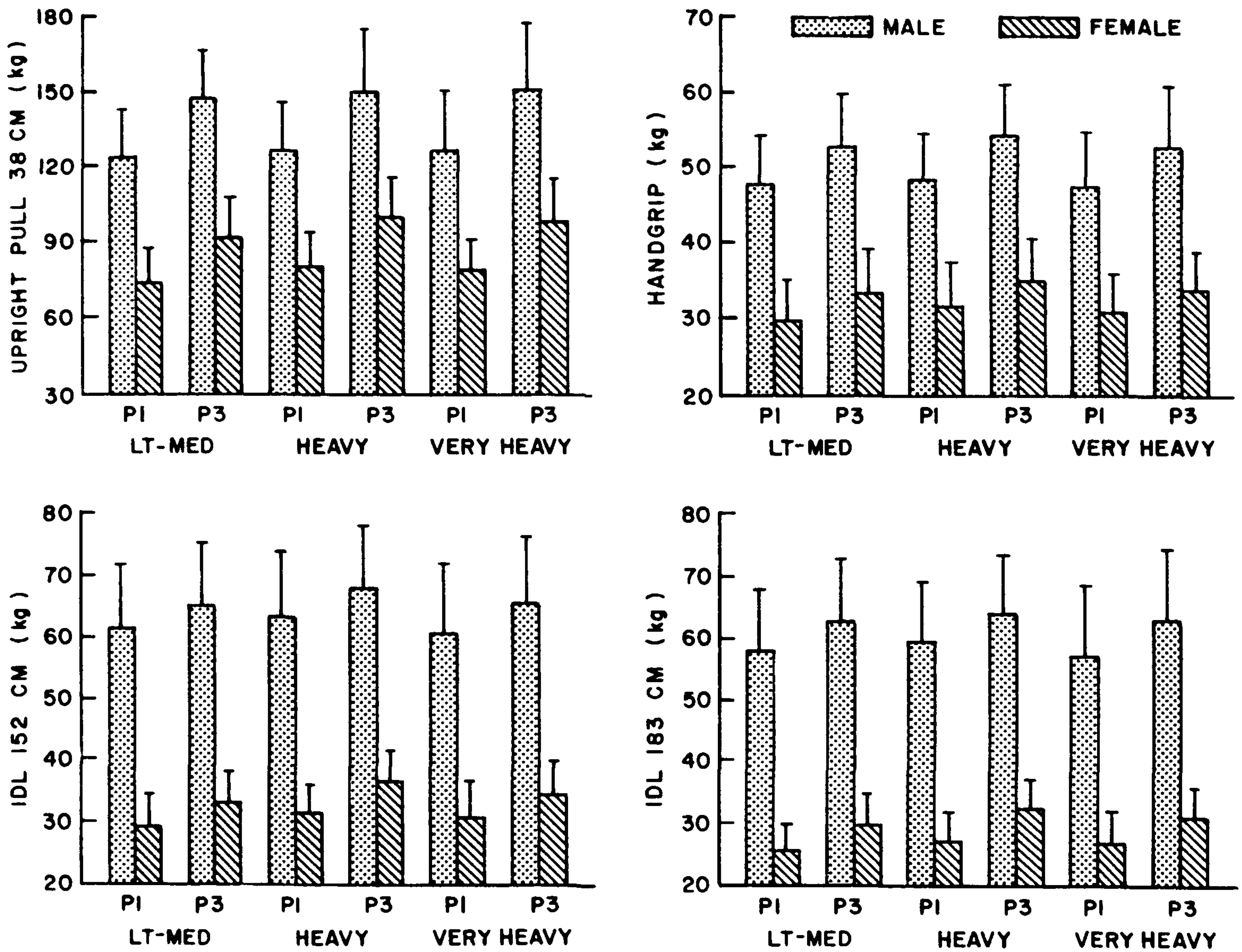


FIGURE 7. PI - P3 STRENGTH INCREASES BY MOS CATEGORY FOR MALES AND FEMALES.

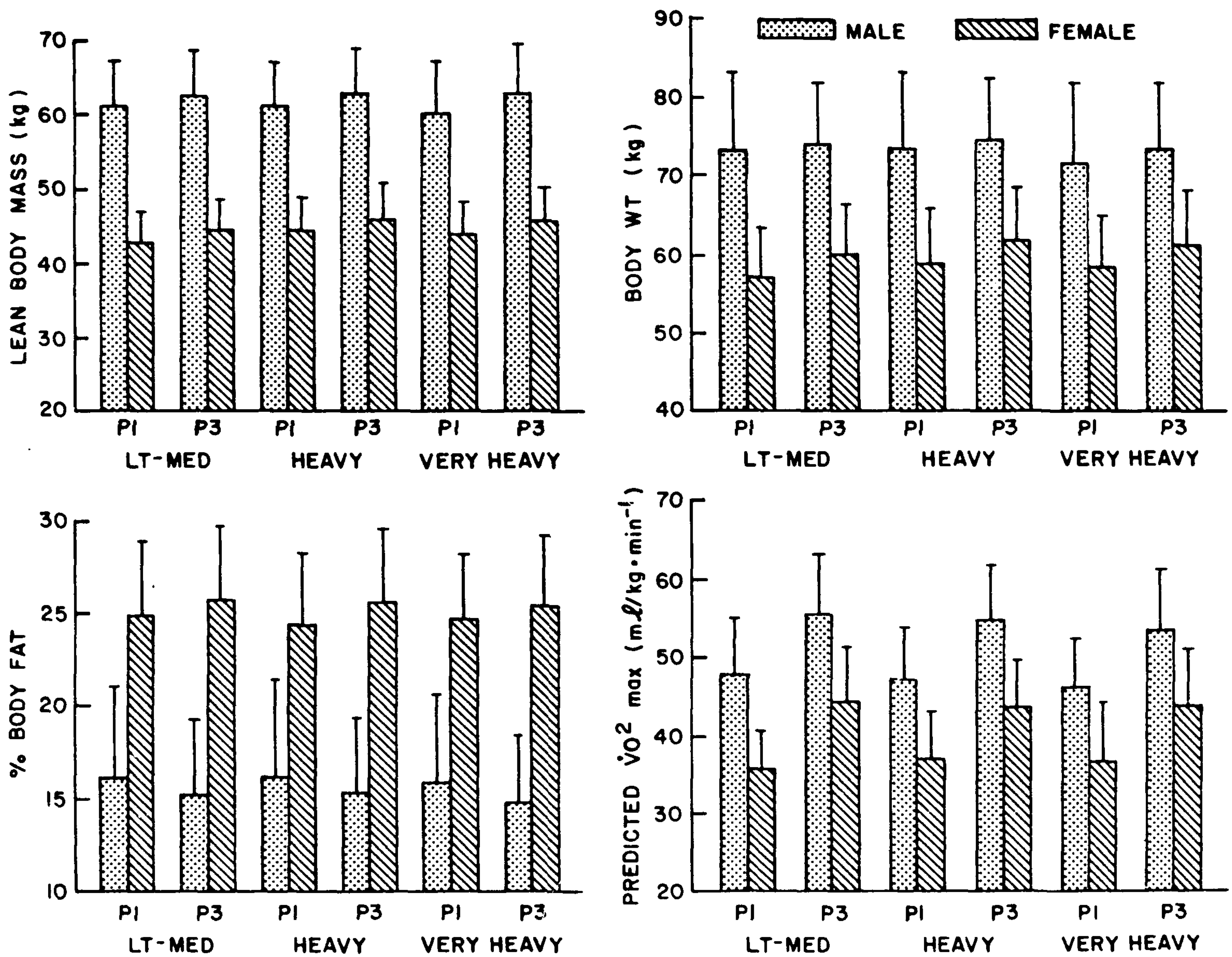


FIGURE 8. CHANGES IN p$\dot{V}O_2$ max AND BODY COMPOSITION PI-P3 BY MOS CATEGORY FOR MALES AND FEMALES.

In summary, these data demonstrate the practical value of a strength screening tool such as the MEPSCAT. The fact that many women were unable to meet the strength requirements of their chosen MOS, and that no significant differences were found between MOS groups, indicates that soldiers are not capable of self selecting an MOS commensurate with their strength capacity.

Prediction of Maximal Lifting Capacity

The Army's main objective in conducting this project was to develop an unbiased means of estimating lifting capacity. Although not formally assigned this task, Maximum Lifting Capacity to 132cm (MLC 132) was included in the test battery as a criterion measure of lifting capacity in an attempt to meet this objective. At the end of BT (P2), a subset of the P1 MEPSCAT sample performed the MEPSCAT candidate test battery including MLC 132. A stepwise multiple regression analysis was performed using selected P1 measures to predict P2 performance. P1 measures were used because the MEPSCAT was to be a pre-enlistment screening tool. A second rationale for collecting the MLC 132 data was to compare it to the earlier work completed by this Institute (19,26).

Eighty-eight males and 107 females completed both P1 and P2 testing. The P2 males were able to lift 78.8 ± 2.3 kg while P2 females lifted 48.4 ± 1.8 kg (Mean±SE). The simple correlation coefficients for the P1 predictor variables and MLC 132 are shown in Table 6 for the whole group, and in Table 7 for males and females separately. MLC 132 was significantly correlated with HT, BW, LBM, and with all strength measures in males and females combined ($p<.01$). When males and females were considered separately, the Pearson product moment correlations dropped appreciably. While the correlations of the combined group

were higher due to a greater range of scores, each predictor variable was more highly correlated with MLC 132 in males than in females. LBM and IDL 183 were the two variables most highly correlated with MLC 132. Since each of these variables accounted for only 43% of the variance associated with MLC 132, they are of little practical significance.

TABLE 6
PEARSON PRODUCT MOMENT CORRELATIONS P1-P2 SUBJECTS*

	SEX	HT1	BW1	PBF	LBM	BF1	HG1	38CM	IDL152	IDL183
HT	-.71	1.0								
BW1	-.66	.74	1.00							
PBF	.74	-.52	-.14	1.00						
LBM	-.87	.85	.91	-.54	1.00					
BF1	.34	-.09	.40	.85	-.03	1.00				
HG1	-.82	.69	.66	-.62	.83	-.24	1.00			
38CM	-.86	.71	.76	-.57	.89	-.14	.89	1.00		
IDL152	-.88	.67	.75	-.59	.89	-.16	.82	.90	1.00	
IDL183	-.89	.68	.75	-.57	.89	-.18	.83	.90	.98	1.00
MLC132	-.59	.53	.57	-.39	.66	-.08	.57	.64	.65	.66

*All measures represent males and females combined, and were collected during P1, with the exception of MLC 132 which was collected P2.
A correlation of .19 required for significance at the .01 level.

TABLE 7
PEARSON PRODUCT MOMENT CORRELATIONS P1-P2 MALES AND FEMALES*

DL183		HT	BW	%BF	LBM	BF1	HG	38CMUP	IDL152	I
BW	M	.42								
	F	.64								
PBF	M	-.04	.75	1.00						
	F	.04	.59	1.00						
LBM	M	.60	.91	.42	1.00					
	F	.75	.88	.15	1.00					
BF	M	.12	.88	.96	.62	1.00				
	F	.33	.85	.92	.51	1.00				
HG	M	.29	.27	-.02	.41	.06	1.00			
	F	.26	.30	-.11	.43	.07	1.00			
38cm	M	.33	.56	.22	.66	.34	.67	1.00		
UP	F	.22	.41	.09	.46	.25	.55	1.00		
IDL	M	.17	.59	.26	.65	.38	.40	.68	1.00	
152	F	.15	.41	.11	.46	.25	.41	.44	1.00	
IDL	M	.28	.58	.20	.68	.34	.41	.68	.93	1.00
183	F	.11	.36	.09	.40	.22	.42	.45	.84	1.00
MLC	M	.23	.34	.06	.45	.13	.30	.44	.41	.44
132	F	.16	.25	.10	.26	.17	.08	.16	.29	.28

*Males, r=.26 required for significance at the p<.01 level.
F=Females, r=.23 required for significance at the p<.01 level.

Wright et al (26) determined simple correlations between MLC 132 and some of the identical anthropometric and strength measures for two groups of enlisted soldiers at Ft Jackson,SC and Ft Stewart,GA during 1978-79. Before any comparisons can be made between the current data and that of Wright et al (26), several differences in the samples measured should be considered. The MEPSCAT P1-P2 sample of 88 males and 107 females was tested prior to and at the end of BT. The Ft Jackson sample was a group of 54 male and 26 female soldiers completing AIT. The Ft Stewart sample consisted of 222 male and 49

female soldiers assigned to the 24th Infantry Division. Fifty-five percent of the MEPSCAT sample were female, while 33% of the Ft Jackson sample and 19% of the Ft Stewart sample were female. A two way analysis of variance of the variables common to the two studies revealed the following differences ($p<.01$) between the three samples:

1. The Ft Stewart group of experienced soldiers was older than the other two groups.

2. The MEPSCAT females had a lower percent body fat and were able to lift more on the MLC 132 than the two other female samples.

3. There were no significant group differences for 38cm UP between the MEPSCAT and Ft Stewart groups.

4. The Ft Jackson sample did not perform the 38cm UP, but had significantly less LBM than the MEPSCAT sample.

5. While the Ft Stewart sample scored as well as the MEPSCAT sample on the strength indices LBM, HG, and 38cm UP, the Ft Stewart males were not able to lift as much weight to 132 cm as the other male samples.

The Mean±SE for MLC 132 of the three groups are illustrated in Table 8.

TABLE 8

COMPARISON OF MLC132 OF THREE INDEPENDENT SAMPLES OF ARMY SOLDIERS

	MEPSCAT	Ft Jackson	Ft Stewart
Male	78.8±2.3	77.2±1.6	58.2±0.9
(n)	(88)	(54)	(222)
Female	48.4±1.8	35.5±1.7	38.3±1.4
(n)	(107)	(26)	(49)

There are several possible explanations for this large difference in criterion measure performance (MLC 132). The Ft Stewart sample was older than the other two samples, and as incumbents, may not have been as motivated to perform the MLC 132. The MEPSCAT sample contained the greatest number of women and may be more representative of the lifting capacity of the female Army population. Although not evidenced in the other strength indices (HG, 38cm UP), in the five years separating these two studies, female participation in

athletics has increased dramatically. An isotonic test, such as MLC 132, is more complex and involves an element of coordination not required of isometric tests. A superior MLC 132 performance by the MEPSCAT females may be a reflection of this growth in women's athletics, resulting in a more coordinated female soldier. Bearing these group differences in mind, a comparison of the correlational and multiple regression analyses can be made.

The correlation coefficients (r) reported by Wright et al (26) are consistently greater than those obtained in the present study. For males and females combined, Wright et al found the correlation between LBM and MLC 132 to be r=.821 and r=.859 for the Ft Jackson and Ft Stewart samples, respectively. For the same variables measured in the same way, the MEPSCAT P2 sample correlation coefficient was r=.66. One possible reason for this is that MEPSCAT subjects were not allowed to lift more than 91 kg on MLC 132 in order to parallel the IDL 152. This limitation probably affected the variability of MLC 132 and therefore the regression analysis.

The multiple regression equation obtained for males and females combined was:

[7] MLC 132=-.55 + .87(LBM) + .55(IDL183) SEE=18.4 kg, R^2=.47.

Using this equation to predict MLC 132 would result in an error of more than 18 kg, more than 50% of the time. The multiple regression analysis was repeated using gender as a predictor variable, and for males and females separately. When gender was included in the variable selection pool, a stepwise multiple regression analysis did not include it in the predictive equation. A stepwise multiple regression analysis for males only resulted in an R^2=.33 and SEE=18.2 kg using age, LBM, and 38cm UP to predict MLC 132. The multiple regression equation for females included LBM and IDL152 with an R^2=.11 and SEE=17.7 kg. Based on these data, none of the MEPSCAT test battery

items are adequate predictors of lifting capacity as measured by MLC 132. It therefore seems unwise to use IDL as a strength screening measure for MOS placement. More data need to be collected to substantiate the relationship between MLC 132 and IDL 152.

CONCLUSIONS

1. Army males proved to be stronger than Army females, in absolute terms and relative to LBM and BW, on all strength measures during P1, P2 and P3. This indicates that factors other than the amount of contractile LBM are responsible for the male/female strength differences observed.

2. The following results indicate that BT and AIT were successful in improving the body composition, strength and aerobic capacity of the soldiers:

a. There was a significant increase in LBM from P1 to P3 in both males and females.

b. Males demonstrated significant increases of 7-16% in all strength measures, while females improved 10-19% from P1 to P3.

c. Predicted maximal oxygen uptake increased approximately 9% for both males and females P1 to P3.

d. Males improved their IDL 152 score by an average of 4.6 kg (7%) and IDL 183 by 5.3kg (8.5%) and females improved by 4.1kg (12%) and 4.2kg (13.8%) on IDL 152 and 183 respectively.

3. Of 406 females tested at both P1 and P3, only 49% were strength qualified for MH and above MOS categories following AIT. Of these, 76 were qualified for HY and VH MOS categories, indicating that less than 20% of all females tested were able to lift enough weight to qualify for HY and VH MOS categories.

4. No differences were found among MOS strength categories on any of the candidate test battery items. Less than 15% of P1 females in the HY and VH MOS categories were strength qualified for their chosen MOS. As soldiers are not likely to select an MOS commensurate with their strength capacity, the data seem to indicate that a strength screening tool is sorely needed.

5. An attempt to predict MLC132 from MEPSCAT candidate test items was unsuccessful. It may be that the strength and coordination needed for a free lift (MLC132) is different than that of a machine lift (IDL).

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APPENDIX I

MEPSCAT Implementation Progress

The Army Research Institute of Behavioral and Social Sciences contracted the Advanced Research Resources Organization (ARRO) to develop and collect data on CPTs. The CPTs were designed to closely represent tasks common to many Army MOS, such as pushing, pulling, lifting and carrying. Extensive statistical analyses were performed by ARRO and resulted in the selection of the IDL 152cm as the single screening tool to be used (14). IDL 152 accounts for 67% of the variance found in the CPTs. LBM, which accounts for an additional 3% of the variance, was not selected as an entrance testing measure.

The initial MOS strength categories (light, moderate, moderately heavy, heavy and very heavy) were grouped into two clusters: light and heavy. The light cluster includes all MOSs with lifting requirements of less than 80 lbs (36 kg). The heavy cluster includes MOSs with lifting requirements ranging from 80-110 lbs (36-50 kg). No Army recruits will be allowed to attempt weights greater than 110lbs (50 kg). The MEPSCAT will be administered at the M ilitary Entrance Processing Station prior to the job counselling session. Recruits falling into the light cluster will be advised to choose an MOS from that cluster. Waivers are available for recruits who do not qualify, but wish to contract for a heavy cluster MOS. The minimum weight attempted is 40 lbs (18.1 kg), but failure to lift 40 lbs will not exclude anyone from entering the Army.

A study advisory group (SAG) has been formed to oversee a follow up study to determine the cost effectiveness and validity of MEPSCAT implementation. A request for bids on the project is now being prepared.

Based on data provided the SAG, 99% of males contracted between 16 January - 23 July, 1984 qualified for the heavy MOS cluster. During this same time period, only 21% of the females qualified for a heavy cluster. Of the females who were unable to lift 80 lbs, 22% received a waiver and signed for a heavy cluster MOS. Less than 1% of the males required a waiver to enter a heavy cluster MOS. Of the 20% of females strength qualified to enter a heavy cluster MOS, half chose to enter a light cluster MOS. For this particular sample, 11% of females and 81% of males entering the Army over a 6 month period were qualified for and selected a heavy cluster MOS. Based on a 1982 report, of the total enlisted positions available, 84% were heavy cluster MOS, with 66% of Army females assigned to these. What these data seem to indicate is that approximately 55% of Army females are not strength qualified for their job. If these females are performing satisfactorily, several conclusions may be proposed:

1. The MOS was not properly categorized.

2. Peace time lifting requirements are much lower than estimates of war time requirements.

3. Females experienced a training effect as a result of performing their MOS.

4. Females devised ways to complete the strength demanding tasks of their MOS, such as working in pairs to lift heavy objects.

5. IDL 152 does not adequately measure the lifting capacity required to perform real world tasks.

Much work remains to be done concerning job recruitment tests and their validity. Perhaps a more fruitful approach will be to examine training procedures to determine the most efficient strength development programs. Changes in the manner in which a task is performed and equipment modification

to decrease the physical strength demands of the very heavy category MOSs are also in order. As these changes are made, the Army will likely experience greater productivity with fewer injuries.

APPENDIX II

Auxiliary Tables with Selected Sub-samples

TABLE 9
P1-P2 DESCRIPTIVE DATA AND MEPSCAT PERFORMANCE SCORES FOR THE TOTAL SAMPLE AND MALES AND FEMALES SEPARATELY (MEAN±SD)

		Combined	Males	Females
n		203	90	113
Age (yrs)	P1	20.0 ± 3.0	19.4 ± 2.3	20.2 ± 3.5
Height(cm)	P1	168.2 ± 8.8	175.2 ± 6.1	162.7 ± 6.2
Weight (kg)	P1	65.1 ± 10.6	72.9 ± 9.6	58.9 ± 6.5
	P2	66.7 ± 9.2	73.5 ± 7.6	61.2 ± 6.3
Percent Body Fat	P1	21.5 ± 6.3	16.3 ± 4.7	25.6 ± 3.9
	P2	19.8 ± 6.1	14.0 ± 3.3	24.3 ± 3.4
Lean Body Mass(kg)	P1	51.2 ± 9.7	60.6 ± 5.7	43.6 ± 3.9
	P2	53.7 ± 9.7	63.0 ± 5.7	46.2 ± 4.1
Body Fat (kg)	P1	13.9 ± 4.5	12.2 ± 5.0	15.3 ± 3.5*
	P2	13.0 ± 3.9	10.4 ± 3.2	15.0 ± 3.1
p$\dot{V}O_2$max (ml/kg/min)	P1	42.0 ± 8.1	46.3 ± 6.5	37.8 ± 7.2
	P2	46.9 ± 9.7	52.3 ± 7.8	41.4 ± 8.2
Handgrip (kg)	P1	37.6 ± 9.8	46.5 ± 6.7	30.5 ± 4.6
	P2	41.8 ± 11.7	52.7 ± 7.8	33.0 ± 4.9
38cm UP (kg)	P1	101.0 ± 28.7	128.4 ± 18.7	79.1 ± 10.9
	P2	112.6 ± 33.3	142.2 ± 21.4	89.0 ± 19.3
IDL 152 (kg)	P1	44.1 ± 17.3	61.1 ± 10.0	30.4 ± 6.1
	P2	47.2 ± 16.7	63.0 ± 9.9	34.7 ± 8.2
IDL 183 (kg)	P1	40.3 ± 16.9	57.2 ± 9.4	26.7 ± 5.2
	P2	43.4 ± 16.9	56.6 ± 10.0	30.4 ± 7.5

*All measures showed significant differences P1-P2, Male vs Female, and P1 - P2 within sex, with the exception of Body Fat in Females P1-P2.

TABLE 10
P1-P2-P3 DESCRIPTIVE DATA AND MEPSCAT PERFORMANCE SCORES FOR THE TOTAL SAMPLE AND MALES AND FEMALES SEPARATELY (MEAN±SD)

		Combined	Males	Females
n		137	57	80
Height(cm)	P1	168.9 ± 9.1	175.3 ± 6.8	162.7 ± 6.2
Weight (kg)	P1	64.4 ± 9.9	72.5 ± 7.7	58.7 ± 6.8
	P2	66.1 ± 8.9	73.2 ± 6.6	61.1 ± 6.7
	P3	66.4 ± 9.4	74.0 ± 7.0	61.1 ± 6.0
Percent Body Fat	P1	21.5 ± 5.9	16.4 ± 3.9	25.3 ± 4.0
	P2	19.7 ± 5.9	13.8 ± 2.8	23.9 ± 3.3
	P3	20.7 ± 6.3	14.6 ± 3.3	25.1 ± 3.9
Lean Body Mass(kg)	P1	50.7 ± 9.4	60.4 ± 5.1	43.7 ± 4.1
	P2	53.3 ± 9.5	63.0 ± 5.4	46.3 ± 4.3
	P3	52.9 ± 10.0	63.1 ± 5.8	45.6 ± 4.5
Body Fat (kg)	P1	13.8 ± 4.0	12.1 ± 3.9	15.0 ± 3.6
	P2	12.8 ± 3.7	10.2 ± 2.5	14.7 ± 3.2
	P3	13.5 ± 4.0	10.9 ± 2.9	15.4 ± 3.6
p$\dot{V}O_2$max (ml/kg/min)	P1	42.7 ± 7.1	46.1 ± 5.7	39.3 ± 6.8
	P2	46.2 ± 9.4	53.3 ± 7.4	44.2 ± 7.7
	P3	48.7 ± 9.5	53.9 ± 8.0	44.1 ± 8.4
Handgrip (kg)	P1	37.0 ± 9.7	46.4 ± 6.0	30.1 ± 4.9
	P2	41.1 ± 11.7	52.8 ± 7.4	32.7 ± 5.2
	P3	41.3 ± 11.3	52.6 ± 6.9	33.2 ± 5.3
38cm UP (kg)	P1	99.0 ± 28.6	127.9 ± 17.7	77.9 ± 11.2
	P2	112.9 ± 31.0	143.3 ± 21.2	90.7 ± 12.8
	P3	117.9 ± 34.1	150.4 ± 23.6	94.1 ± 16.3
IDL 152 (kg)	P1	43.2 ± 16.5	60.3 ± 9.3	30.6 ± 5.5
	P2	46.7 ± 15.6	62.6 ± 9.6	35.3 ± 6.1
	P3	47.5 ± 16.9	65.2 ± 9.9	34.8 ± 5.6
IDL 183 (kg)	P1	39.4 ± 16.1	56.4 ± 8.4	26.7 ± 4.6
	P2	42.6 ± 15.7	58.8 ± 9.3	30.9 ± 5.7
	P3	44.2 ± 17.2	62.0 ± 10.6	31.3 ± 5.4

TABLE 11
MUSCLE STRENGTH MEASURES MADE RELATIVE TO BODY WEIGHT AND LEAN BODY MASS IN MALES AND FEMALES (MEAN and SD)

		MALES			FEMALES		
n		465			485		
Handgrip/BW	P1	0.66	±	0.10	0.53	±	0.09
	P3	0.71	±	0.09	0.55	±	0.08
Handgrip/LBM	P1	0.79	±	0.10	0.70	±	0.11
	P3	0.84	±	0.10	0.74	±	0.10
38cm UP/BW	P1	1.74	±	0.26	1.33	±	0.21
	P3	2.02	±	0.31	1.57	±	0.26
38cm UP/LBM	P1	2.07*	±	0.29	1.77	±	0.25
	P3	2.38	±	0.35	2.11*	±	0.34
IDL 152/BW	P1	0.85	±	0.12	0.52	±	0.08
	P3	0.89	±	0.12	0.57	±	0.08
IDL 152/LBM	P1	1.01	±	0.14	0.70	±	0.10
	P3	1.05	±	0.13	0.76	±	0.10
IDL 183/BW	P1	0.79	±	0.11	0.45	±	0.08
	P3	0.84	±	0.12	0.50	±	0.08
IDL 183/LBM	P1	0.94	±	0.13	0.60	±	0.09
	P3	0.99	±	0.13	0.67	±	0.10

*All measures showed significant differences ($p<.01$) P1-P3, male vs female, and P1-P3 within sex, with the exception of P1 Males vs P3 females 38cm UP/LBM.

TABLE 12

PRE BASIC TRAINING MEPSCAT PERFORMANCE OF MALES AND FEMALES BY MOS CATEGORY ($\bar{X}$ and SD)

	LT MED		MED HEAVY		HEAVY		VERY HEAVY	
	Male	Female	Male	Female	Male	Female	Male	Female
n	236	331	49	48	126	181	56	44
Age	19.5	19.9	19.5	20.6	19.4	20.3	19.6	20.8
(yrs)	2.4	3.0	3.4	3.2	2.3	3.2	2.5	3.6
Height	175.6	162.3	173.0	163.4	175.8	162.9	174.9	162.7
(cm)	6.5	6.2	7.0	6.3	6.5	6.5	6.9	6.3
Body Weight	73.7	57.8	69.0	60.5	73.8	59.0	72.6	58.5
(kg)	9.9	6.3	9.3	6.7	11.5	7.2	11.1	6.7
Percent Body Fat	16.0	25.2	16.4	25.3	15.8	24.8	16.4	25.0
(%)	5.0	4.1	5.3	3.7	5.2	4.1	5.2	3.8
Lean Body Mass	61.6	43.1	57.3	45.1	61.7	44.2	60.3	43.7
(kg)	6.2	4.0	6.1	4.3	6.9	4.4	6.9	4.2
Body Fat	12.1	14.7	11.6	15.4	12.1	14.8	12.3	14.8
(kg)	5.1	3.4	5.0	3.4	5.7	3.8	5.6	3.4
p$\dot{V}O_2$max	47.7	36.0	45.2	36.2	47.7	36.9	46.4	36.6
($ml/kg.min^{-1}$)	7.4	5.7	7.0	6.8	8.6	7.2	6.9	7.4
Handgrip	47.9	29.7	45.5	31.6	48.8	30.8	47.1	30.2
(kg)	6.8	5.6	7.9	5.2	7.1	5.4	7.4	5.4
38cm Upright	125.9	74.9	121.4	81.4	127.5	79.2	124.2	77.4
Pull (kg)	20.0	13.9	22.0	13.9	22.0	13.5	21.4	12.9
IDL 152	61.9	29.1	57.5	30.2	62.2	30.8	60.0	30.0
(kg)	10.2	5.5	11.0	4.5	11.2	4.7	10.6	5.6
IDL 183	57.9	25.1	53.4	25.8	58.3	26.4	56.1	25.7
(kg)	10.1	4.6	10.5	4.2	11.0	4.4	10.4	4.9

TABLE 13
POST BASIC TRAINING MEPSCAT PERFORMANCE OF MALES AND FEMALES
BY MOS CATEGORY ($\bar{X}$ and SD)

	LT MED		MED HEAVY		HEAVY		VERY HEAVY	
	Male	Female	Male	Female	Male	Female	Male	Female
n	15	37	9	5	12	25	54	46
Age	19.4	19.8	19.9	19.4	18.8	20.2	19.7	21.2
(yrs)	1.6	3.3	2.7	1.5	0.9	3.1	2.5	3.8
Height	176.9	160.9	170.9	159.0	175.7	164.8	175.4	163.6
(cm)	4.5	6.3	4.5	3.5	6.7	6.1	6.6	6.2
Body Weight	77.2	59.8	69.9	60.3	75.4	61.7	72.6	62.2
(kg)	7.4	5.7	6.5	4.6	8.2	6.3	7.3	6.8
Percent Body Fat	14.6	24.3	14.2	24.9	15.0	23.7	13.6	24.7
(%)	3.8	3.1	4.5	4.7	3.5	3.8	3.0	3.2
Lean Body Mass	65.8	45.2	59.9	45.2	63.9	47.0	62.6	46.7
(kg)	5.4	3.7	5.5	2.9	6.2	4.0	5.4	4.5
Body Fat	11.4	14.6	10.0	15.1	11.5	14.8	10.0	15.5
(kg)	3.6	2.8	3.6	3.6	3.5	3.4	3.0	3.2
$p\dot{V}O_2max$	52.0	40.4	52.6	40.8	51.6	40.7	51.5	40.8
($ml/kg.min^{-1}$)	7.1	6.1	10.5	12.7	7.7	9.2	7.8	7.5
Handgrip	52.2	32.7	50.0	34.9	53.5	32.6	51.2	33.4
(kg)	7.3	4.7	11.4	1.6	7.7	5.3	7.4	5.1
38cm Upright	144.7	89.4	133.8	94.3	148.1	89.8	141.6	93.5
Pull (kg)	24.3	12.3	18.6	10.1	24.3	12.9	20.3	12.8
IDL 152	64.2	34.9	62.1	36.4	64.8	34.9	62.4	36.5
(kg)	13.4	6.6	8.5	4.5	11.3	6.0	8.9	5.7
IDL 183	61.5	30.0	57.0	32.8	61.7	31.3	59.1	32.0
(kg)	13.3	4.9	8.8	5.0	10.5	6.1	9.0	6.0
Max Lift	74.3	52.5	73.0	40.6	86.1	45.4	79.6	48.0
Capacity 132cm	24.4	19.5	26.9	21.2	16.0	19.9	21.2	16.8

TABLE 14
POST AIT MEPSCAT PERFORMANCE OF MALES AND FEMALES
BY MOS CATEGORY ($\overline{X}$ and SD)

	LT MED		MED HEAVY		HEAVY		VERY HEAVY	
	Male	Female	Male	Female	Male	Female	Male	Female
n	113	151	13	3	71	130	270	202
Age	19.6	20.0	19.8	26.3	19.2	20.2	19.6	21.1
(yrs)	2.0	2.9	3.9	4.7	1.7	2.8	2.2	3.6
Height	175.8	161.9	175.2	159.6	175.3	163.5	175.0	163.0
(cm)	7.0	6.0	8.1	5.8	6.2	6.5	6.8	6.3
Body Weight	74.2	60.0	73.1	59.6	74.5	61.7	73.6	61.5
(kg)	8.0	6.5	11.2	9.2	7.7	7.0	8.7	7.1
Percent Body Fat	15.2	25.8	16.9	26.6	15.5	25.6	14.9	25.6
(%)	4.1	3.9	4.3	4.2	3.9	4.0	3.6	3.6
Lean Body Mass	62.8	44.4	60.5	43.5	62.8	45.8	62.5	45.6
(kg)	6.1	4.3	7.9	4.2	5.8	4.8	6.5	4.3
Body Fat	11.4	15.6	12.6	16.1	11.7	15.9	11.1	15.9
(kg)	3.7	3.4	4.5	5.1	3.7	3.6	3.6	3.7
$\dot{V}O_2max$	54.5	43.1	48.4	40.6	53.2	42.8	52.8	42.8
($ml/kg.min^{-1}$)	7.6	7.0	6.5	6.8	7.3	6.2	7.8	7.5
Handgrip	52.8	33.2	53.0	35.9	53.8	34.6	52.1	33.4
(kg)	7.0	5.8	8.5	2.1	6.8	5.8	8.1	5.2
38cm Upright	147.1	91.2	151.7	83.3	147.9	98.0	149.3	96.5
Pull (kg)	19.9	16.5	25.4	4.9	24.8	16.0	26.5	17.7
IDL 152	65.3	33.0	69.2	33.3	67.3	36.2	64.9	34.3
(kg)	10.1	5.2	16.2	9.5	10.0	5.3	10.7	5.8
IDL 183	62.4	29.5	64.3	33.3	63.4	31.5	61.7	30.4
(kg)	10.0	4.9	17.0	9.5	9.4	4.9	11.3	5.0

TABLE 11
P1-P2 MUSCLE STRENGTH MEASURES MADE RELATIVE TO BODY WEIGHT AND LEAN BODY MASS IN MALES AND FEMALES (MEAN and SD)

		MALES			FEMALES		
n		90			113		
Handgrip/BW	P1	0.64	±	0.10	0.52	±	0.08
	P2	0.72	±	0.10	0.54	±	0.08
Handgrip/LBM	P1	0.77	±	0.10	0.70	±	0.10
	P2	0.84	±	0.10	0.72	±	0.09
38cm UP/BW	P1	1.77	±	0.22	1.35	±	0.19
	P2	1.94	±	0.24	1.46	±	0.31
38cm UP/LBM	P1	2.11	±	0.23	1.82	±	0.23
	P2	2.25	±	0.25	1.93	±	0.40
IDL 152/BW	P1	0.84	±	0.11	0.52	±	0.10
	P2	0.86	±	0.11	0.57	±	0.13
IDL 152/LBM	P1	1.01	±	0.12	0.70	±	0.13
	P2	1.00	±	0.12	0.75	±	0.17
IDL 183/BW	P1	0.79	±	0.10	0.46	±	0.09
	P2	0.81	±	0.11	0.50	±	0.12
IDL 183/LBM	P1	0.94	±	0.11	0.61	±	0.12
	P2	0.94	±	0.12	0.66	±	0.16
MLC 132/BW	P1						
	P2	1.04	±	0.32	0.75	±	0.34
MLC 132/LBM	P1						
	P2	1.21	±	0.37	0.99	±	0.45

*All measures showed significant differences ($p<.01$) P1-P3, male vs female, and P1-P3 within sex, with the exception of P1 Males vs P3 females 38cm UP/LBM.

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